CLAIMS

What is claimed as new and desired to be protected by Letters Patent of the United States is:

1. A photoconversion device comprising:

a substrate having a surface;

a first region doped to a first conductivity type located below the surface of the substrate, said region having a graded profile; and

a second region doped to a second conductivity type located beneath said first doped region for collecting photogenerated charges.

2. The photoconversion device of claim 1, wherein said first conductivity type is p-type.

3. The photoconversion device of claim 1, wherein said second conductivity type is n-type.

4. The photoconversion device of claim 1, wherein said graded profile further comprises a first sub-region doped to a first dopant

concentration and a second sub-region doped to a second dopant concentration.

5. The photoconversion device of claim 4, further comprising a third sub-region having no dopant ions from said first and second doped sub-regions.

6. The photoconversion device of claim 4, wherein said first dopant concentration is a p+ dopant concentration and said second dopant concentration is less than a p+ dopant concentration.

7. The photoconversion device of claim 4, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

8. The photoconversion device of claim 7, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

9. The photoconversion device of claim 4, wherein said second dopant concentration is from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

10. The photoconversion device of claim 9, wherein said second dopant concentration is from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

11. The photoconversion device of claim 6, wherein said p+ doped sub-region primarily sets the pinning voltage of said photoconversion device.

12. The photoconversion device of claim 4, wherein said first dopant concentration is greater than said second dopant concentration.

13. The photoconversion device of claim 4, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

14. The photoconversion device of claim 13, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 15 degrees.

15. The photoconversion device of claim 4, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

16. The photoconversion device of claim 15, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 10 degrees.

17. The photoconversion device of claim 4, wherein said first and second doped region is implanted with BF_2 or B^{11} dopant ions.

18. The photoconversion device of claim 17, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

19. The photoconversion device of claim 18, wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

20. The photoconversion device of claim 4, wherein said second doped sub-region has a shallower doping profile than said first doped region.

21. The photoconversion device of claim 4, wherein said second doped sub-region is adjacent to an undoped sub-region.

22. The photoconversion device of claim 1, wherein said photoconversion device is part of a CMOS imager.

23. The photoconversion device of claim 22, wherein said CMOS Imager is a 3T, 4T, 5T, 6T, or 7T device.

24. The photoconversion device of claim 1, wherein said photoconversion device is part of a CCD imager.

25. The photoconversion device of claim 1, wherein said second conductivity is provided from the group comprising of arsenic, antimony, or phosphorus ions.

26. The photoconversion device of claim 1, wherein said second doped region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

27. The photoconversion device of claim 26, wherein said second doped region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

28. The photoconversion device of claim 1, wherein said second doped region is formed with an implant energy of from about 30 keV to about 300 keV.

29. The photoconversion device of claim 28, wherein said second doped region is formed with an implant energy of from about 50 keV to about 200 keV.

30. A photoconversion device comprising:

a substrate having a surface;

a first region doped to a first conductivity type located below the surface of the substrate;

a second region adjacent to said first region; and

a third region doped to a second conductivity type located beneath said first doped region for collecting photogenerated charges.

31. The photoconversion device of claim 30, wherein said first conductivity type is p-type.

32. The photoconversion device of claim 30, wherein said second conductivity type is n-type.

33. The photoconversion device of claim 30, wherein said first region doped has a first dopant concentration.

34. The photoconversion device of claim 30, wherein said second region does not have a dopant concentration of said first conductivity type.

35. The photoconversion device of claim 34, wherein said first dopant concentration is a p+ dopant concentration.

36. The photoconversion device of claim 35, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

37. The photoconversion device of claim 36, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

38. The photoconversion device of claim 30, wherein said first doped region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

39. The photoconversion device of claim 38, wherein said first doped region is formed with an angled implantation having an angle from about 5 to about 15 degrees.

40. The photoconversion device of claim 30, wherein said first doped region is implanted with BF_2 or B^{11} dopant ions.

41. The photoconversion device of claim 40, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

42. The photoconversion device of claim 41, wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

43. The photoconversion device of claim 30, wherein said photoconversion device is part of a CMOS imager.

44. The photoconversion device of claim 43, wherein said CMOS Imager is a 3T, 4T, 5T, 6T, or 7T device.

45. The photoconversion device of claim 30, wherein said photoconversion device is part of a CCD imager.

46. The photoconversion device of claim 30, wherein said second conductivity is provided from the group comprising of arsenic, antimony, or phosphorus ions.

47. The photoconversion device of claim 30, wherein said third doped region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

48. The photoconversion device of claim 47, wherein said third doped region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

49. The photoconversion device of claim 30, wherein said third doped region is formed with an implant energy of from about 30 keV to about 300 keV.

50. The photoconversion device of claim 49, wherein said third doped region is formed with an implant energy of from about 50 keV to about 200 keV.

51. A photodiode structure comprising:

a first doped region of a first conductivity type in contact with a second undoped region; and

a third doped region in contact with said first doped region.

52. A photodiode structure as in claim 51, wherein said first doped region further comprises a first sub-region and second sub-region.

53. A photodiode structure as in claim 52, wherein said second sub-region has a shallower doping profile than said first sub-region.

54. A photodiode as in claim 52, wherein said first sub-region is doped to a p-type conductivity having a dopant concentration of from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

55. A photodiode as in claim 54, wherein said first sub-region is doped to a p-type conductivity having a dopant concentration of from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

56. A photodiode as in claim 52, wherein said second sub-region is doped to a p-type conductivity having a dopant concentration of from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

57. A photodiode as in claim 56, wherein said second sub-region is doped to a p-type conductivity having a dopant concentration of from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

58. A photodiode as in claim 52, wherein said first sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

59. A photodiode as in claim 52, wherein said second sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

60. A photodiode as in claim 51, wherein said first doped region is formed with BF_2 or B^{11} dopant ions.

61. A photodiode as in claim 51, wherein said first doped region is formed with an implant energy of from about 1 keV to about 40 keV.

62. A photodiode as in claim 52, wherein said second sub-region is adjacent to and in contact with said second undoped region.

63. A photodiode as in claim 51, wherein said third doped region is formed with arsenic, antimony or phosphorus dopant ions.

64. A photodiode as in claim 51, wherein said third doped region is formed with an implant energy of from about 30 keV to about 300 keV.

65. A photodiode as in claim 51, wherein said third doped region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

66. A photodiode as in claim 51, wherein said structure is part of a CMOS imager.

67. A photodiode as in claim 51, wherein said structure is part of a CCD imager.

68. An image pixel structure, comprising:

a substrate;

a transistor provided over said substrate; and

a photodiode having a pinned surface layer and a charge collection region, wherein said pinned surface layer has an undoped region that is adjacent to said transistor.

69. The structure of claim 68, wherein said pinned surface layer has a conductivity type that is p-type.

70. The structure of claim 68, wherein said charge collection region has a second conductivity type that is n-type.

71. The structure of claim 68, wherein said pinned surface layer further comprises a first doped sub-region with a first dopant concentration and a second doped sub-region with a second dopant concentration.

72. The structure of claim 68, wherein said undoped region has no photodiode dopant ions.

73. The structure of claim 71, wherein said first dopant concentration is a p+ dopant concentration and said second dopant concentration is less than a p+ dopant concentration.

74. The structure of claim 71, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

75. The structure of claim 74, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

76. The structure of claim 71, wherein said second dopant concentration is from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

77. The structure of claim 76, wherein said second dopant concentration is from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

78. The structure of claim 71, wherein said first dopant concentration is greater than said second dopant concentration.

79. The structure of claim 71, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

80. The structure of claim 79, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 15 degrees.

81. The structure of claim 71, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

82. The structure of claim 81, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 10 degrees.

83. The structure of claim 71, wherein said first and second doped sub-regions are implanted with BF_2 or B^{11} dopant ions.

84. The structure of claim 83, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

85. The structure of claim 84, wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

86. The structure of claim 71, wherein said second doped sub-region has a shallower doping profile than said first doped region.

87. The structure of claim 68, wherein said structure is a CMOS imager structure.

88. The structure of claim 87, wherein said CMOS Imager is a , 3T 4T, 5T, 6T, or 7T structure.

89. The structure of claim 68, wherein said structure is a CCD imager structure.

90. The structure of claim 68, wherein said charge collection region is formed with dopant ions from the group comprising of arsenic, antimony, or phosphorus.

91. The structure of claim 68, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

92. The structure of claim 91, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

93. The structure of claim 68, wherein said charge collection region is formed with an implant energy of from about 30 keV to about 300 keV.

94. The structure of claim 68, wherein said charge collection region is formed with an implant energy of from about 50 keV to about 200 keV.

95. The structure of claim 68, wherein said transistor is at least one of a transfer transistor, reset transistor, global shutter transistor, high dynamic range transistor, lateral overflow drain transistor, or storage gate transistor.

96. An image pixel structure, comprising:

a semiconductor substrate;

a transistor provided over said substrate; and

a pinned photodiode adjacent to said transistor, said pinned photodiode having an undoped surface region in contact with a doped surface region of said pinned photodiode, wherein said doped surface region is in contact with the charge collection region of said pinned photodiode.

97. The structure of claim 96, wherein said doped surface region has p-type conductivity.

98. The structure of claim 96, wherein said charge collection region has n-type conductivity.

99. The structure of claim 96, wherein said doped surface region further comprises a first doped sub-region with a first dopant concentration and a second doped sub-region with a second dopant concentration.

100. The structure of claim 96, wherein said undoped surface region has no photodiode implant ions.

101. The structure of claim 99, wherein said first dopant concentration is greater than said second dopant concentration.

102. The structure of claim 99, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

103. The structure of claim 102, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

104. The structure of claim 99, wherein said second dopant concentration is from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

105. The structure of claim 104, wherein said second dopant concentration is from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

106. The structure of claim 99, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

107. The structure of claim 106, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 15 degrees.

108. The structure of claim 99, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

109. The structure of claim 108, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 10 degrees.

110. The structure of claim 99, wherein said first and second doped sub-regions are implanted with BF_2 or B^{11} dopant ions.

111. The structure of claim 110, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

112. The structure of claim 111 wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

113. The structure of claim 99, wherein said second doped sub-region has a shallower doping profile than said first doped sub-region.

114. The structure of claim 96, wherein said structure is a CMOS imager structure.

115. The structure of claim 114, wherein said CMOS Imager is a 3T, 4T, 5T, 6T, or 7T structure.

116. The structure of claim 96, wherein said structure is a CCD imager structure.

117. The structure of claim 96, wherein said charge collection region is formed with dopant ions from the group comprising of arsenic, antimony, or phosphorus.

118. The structure of claim 96, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

119. The structure of claim 118, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

120. The structure of claim 96, wherein said charge collection region is formed with an implant energy of from about 30 keV to about 300 keV.

121. The structure of claim 120, wherein said charge collection region is formed with an implant energy of from about 50 keV to about 200 keV.

122. The structure of claim 96, wherein said transistor is at least one of a transfer transistor, reset transistor, global shutter transistor, high dynamic range transistor, lateral overflow drain transistor, or storage gate transistor.

123. A method of forming a photoconversion device, said method comprising:

providing a substrate having a top surface;

providing an oxide layer over the top surface of said substrate;

forming a first doped region through said oxide layer with at least a portion doped to a first conductivity type located below the surface of the substrate; and

forming a second doped region through said oxide layer doped to a second conductivity type located beneath said first doped region for collecting photogenerated charges.

124. The method of claim 123, wherein said oxide layer is from about 20 Å to about 1000 Å thick.

125. The method of claim 124, wherein said oxide layer is from about 20 Å to about 300 Å thick.

126. The method of claim 125, wherein said oxide layer is from about 20 Å to about 100 Å thick.

127. The method of claim 123, wherein said first conductivity type is p-type.

128. The method of claim 123, wherein said second conductivity type is n-type.

129. The method of claim 123, wherein said first doped region is formed with a doped portion and an undoped portion.

130. The method of claim 129, wherein said doped portion comprises a first sub-region doped to a first dopant concentration and a second sub-region doped to a second dopant concentration.

131. The method of claim 129, wherein said undoped portion is formed having no photodiode dopant ions of a first conductivity type.

132. The method of claim 130, wherein said first dopant concentration is greater than said second dopant concentration.

133. The method of claim 130, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

134. The method of claim 133, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

135. The method of claim 130, wherein said second dopant concentration is from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

136. The method of claim 130, wherein said second dopant concentration is from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

137. The method of claim 130, wherein said first sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

138. The method of claim 137, wherein said first sub-region is formed with an angled implantation having an angle from about 2 to about 15 degrees.

139. The method of claim 130, wherein said second sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

140. The method of claim 139, wherein said second sub-region is formed with an angled implantation having an angle from about 0 to about 10 degrees.

141. The method of claim 130, wherein said first and second sub-regions are implanted with BF_2 or B^{11} dopant ions.

142. The method of claim 141, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

143. The method of claim 137, wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

144. The method of claim 130, wherein said second sub-region has a shallower doping profile than said first sub-region.

145. The method of claim 130 wherein said second sub-region is adjacent to said undoped region.

146. The method of claim 123, wherein said second doped region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

147. The method of claim 146, wherein said second doped region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

148. The method of claim 123, wherein said second doped region is formed with an implant energy of from about 30 keV to about 300 keV.

149. The method of claim 148, wherein said second doped region is formed with an implant energy of from about 50 keV to about 200 keV.

150. The method of claim 123, wherein said second doped region is formed with n-type dopant ions selected from the group comprising arsenic, antimony, or phosphorus.

151. The method of claim 130, wherein said first region and second sub-regions are formed with dual angled implants.

152. The method of claim 123, wherein said first doped region is formed with at least one angled implant.

153. The method of claim 123, wherein said second doped region is formed with at least one angled implant.

154. A method of forming a photodiode structure, said method comprising:

forming a first doped region of a first conductivity type in contact with a second undoped region; and

forming a third doped region in contact with said first doped region.

155. The method of claim 154, wherein said first doped region further comprises a first sub-region and second sub-region.

156. The method of claim 155, wherein said second sub-region has a shallower doping profile than said first sub-region.

157. The method of claim 155, wherein said first sub-region is doped to a p-type conductivity having a dopant concentration of from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

158. The method of claim 157, wherein said first sub-region is doped to a p-type conductivity having a dopant concentration of from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

159. The method of claim 155, wherein said second sub-region is doped to a p-type conductivity having a dopant concentration of from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

160. The method of claim 159, wherein said second sub-region is doped to a p-type conductivity having a dopant concentration of from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

161. The method of claim 155, wherein said first sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

162. The method of claim 155, wherein said second sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

163. The method of claim 154, wherein said first doped region is formed with BF_2 or B^{11} dopant ions.

164. The method of claim 154, wherein said first doped region is formed with an implant energy of from about 1 keV to about 40 keV.

165. The method of claim 155, wherein said second sub-region is adjacent to and in contact with said second undoped region.

166. The method of claim 154, wherein said third doped region is formed with arsenic, antimony or phosphorus dopant ions.

167. The method of claim 154, wherein said third doped region is formed with an implant energy of from about 30 keV to about 300 keV.

168. The method of claim 154, wherein said third doped region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

169. The method of claim 154, wherein said first and third doped regions are formed through an oxide layer.

170. The method of claim 169, wherein said oxide layer is from about 20 Å to about 1000 Å thick.

171. The method of claim 170, wherein said oxide layer is from about 20 Å to about 300 Å thick.

172. The method of claim 171, wherein said oxide layer is from about 20 Å to about 100 Å thick.

173. A method for forming an image pixel structure, said method comprising:

forming a substrate;

forming a transistor gate stack; and

forming a photodiode through an oxide layer having a pinned surface layer and a charge collection region, wherein said pinned surface layer is formed to have an undoped region and doped region that is laterally offset from said transistor.

174. The method of claim 173, wherein said pinned surface layer has a conductivity type that is p-type.

175. The method of claim 173, wherein said charge collection region has a second conductivity type that is n-type.

176. The method of claim 173, wherein said doped region is formed to have a first doped sub-region with a first dopant concentration and a second doped sub-region with a second dopant concentration.

177. The method of claim 173, wherein said undoped region has no photodiode dopant ions.

178. The method of claim 176, wherein said first dopant concentration is greater than said second dopant concentration.

179. The method of claim 176, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

180. The method of claim 179, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

181. The method of claim 176, wherein said second dopant concentration is from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

182. The method of claim 181, wherein said second dopant concentration is from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

183. The method of claim 176, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

184. The method of claim 183, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 15 degrees.

185. The method of claim 176, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

186. The method of claim 185, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 10 degrees.

187. The method of claim 176, wherein said first and second doped sub-regions are implanted with BF_2 or B^{11} dopant ions.

188. The method of claim 187, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

189. The method of claim 188, wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

190. The method of claim 176, wherein said second doped sub-region has a shallower doping profile than said first doped sub-region.

191. The method of claim 176, wherein said first doped sub-region is laterally offset from said transistor by a distance L_a.

192. The method of claim 191, wherein said distance L_a is equal to the transistor's gate stack height multiplied by $\tan\theta_a$, where θ_a is in the range from about 2 to about 30 degrees.

193. The method of claim 173, wherein said doped region is laterally offset from said transistor by a distance L_a.

194. The method of claim 193, wherein said distance L_a is equal to the transistor's gate stack height multiplied by $\tan\theta_a$, where θ_a is in the range from about 2 to about 30 degrees.

195. The method of claim 176, wherein said second doped sub-region is laterally offset from said transistor by a distance L_b.

196. The method of claim 195, wherein said distance L_b is equal to the transistor's gate stack height multiplied by $\mathrm{Tan}\theta_b$, where θ_b is in the range from about 0 to about 15 degrees.

197. The method of claim 173, wherein said charge collection region is formed with dopant ions from the group comprising of arsenic, antimony, or phosphorus.

198. The method of claim 173, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

199. The method of claim 198, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

200. The method of claim 173, wherein said charge collection region is formed with an implant energy of from about 30 keV to about 300 keV.

201. The method of claim 200, wherein said charge collection region is formed with an implant energy of from about 50 keV to about 200 keV.

202. The method of claim 165, wherein said transistor is at least one of a transfer transistor, reset transistor, global shutter transistor, high dynamic range transistor, lateral overflow drain transistor, or storage gate transistor.

203. A method of forming an image pixel structure, said method comprising:

providing a semiconductor substrate;

forming a gate stack by etching at least one gate oxide layer and a conductor layer;

forming a source/drain oxidation layer through a source/drain oxidation process;

forming a pinned photodiode through said source/drain oxidation layer adjacent to said gate stack, said pinned photodiode having an undoped surface region in contact with a doped surface region of said pinned photodiode, wherein said doped surface region is in contact with the charge collection region of said pinned photodiode; and

forming sidewall spacers on at least one side of said gate stack.

204. The method of claim 203, wherein said source/drain oxidation layer is from about 20 Å to about 100 Å thick.

205. The method of claim 203, wherein said doped surface region has p-type conductivity.

206. The method of claim 203, wherein said charge collection region has n-type conductivity.

207. The method of claim 203, wherein said doped surface region further comprises a first doped sub-region with a first dopant concentration and a second doped sub-region with a second dopant concentration.

208. The method of claim 203, wherein said undoped surface region has no photodiode dopant ions.

209. The method of claim 207, wherein said first dopant concentration is greater than said second dopant concentration.

210. The method of claim 207, wherein said first dopant concentration is from about $2.0 \times 10^{12}/cm^2$ to about $1.0 \times 10^{14}/cm^2$.

211. The method of claim 210, wherein said first dopant concentration is from about $6.0 \times 10^{12}/cm^2$ to about $5.0 \times 10^{13}/cm^2$.

212. The method of claim 207, wherein said second dopant concentration is from about $1.0 \times 10^{12}/cm^2$ to about $6.0 \times 10^{13}/cm^2$.

213. The method of claim 212, wherein said second dopant concentration is from about $3.0 \times 10^{12}/cm^2$ to about $4.0 \times 10^{13}/cm^2$.

214. The method of claim 207, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 30 degrees.

215. The method of claim 214, wherein said first doped sub-region is formed with an angled implantation having an angle from about 2 to about 15 degrees.

216. The method of claim 207, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

217. The method of claim 216, wherein said second doped sub-region is formed with an angled implantation having an angle from about 0 to about 10 degrees.

218. The method of claim 207, wherein said first and second doped sub-regions are implanted with BF_2 or B^{11} dopant ions.

219. The method of claim 218, wherein said dopant ions are implanted with an implant energy of from about 1 keV to about 40 keV.

220. The method of claim 219, wherein said dopant ions are implanted with an implant energy of from about 3 keV to about 20 keV.

221. The method of claim 207, wherein said second doped sub-region has a shallower doping profile than said first doped sub-region.

222. The method of claim 203, wherein said charge collection region is formed with dopant ions from the group comprising of arsenic, antimony, or phosphorus.

223. The method of claim 203, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 30 degrees.

224. The method of claim 223, wherein said charge collection region is formed with an angled implantation having an angle from about 0 to about 15 degrees.

225. The method of claim 203, wherein said charge collection region is formed with an implant energy of from about 30 keV to about 300 keV.

226. The method of claim 225, wherein said charge collection region is formed with an implant energy of from about 50 keV to about 200 keV.

227. The method of claim 203, wherein said gate stack is at least one of a transfer transistor, reset transistor, global shutter transistor, high

dynamic range transistor, lateral overflow drain transistor, or storage gate transistor.

228. The method of claim 207, wherein said first doped sub-region is laterally offset from said gate stack by a distance L_a.

229. The method of claim 228, wherein said distance L_a is equal to the gate stack's height multiplied by $\mathrm{Tan}\theta_a$, where θ_a is in the range from about 2 to about 30 degrees.

230. The method of claim 203, wherein said doped region is laterally offset from said gate stack by a distance L_a.

231. The method of claim 230, wherein said distance L_a is equal to the gate stack's height multiplied by $\mathrm{Tan}\theta_a$, where θ_a is in the range from about 2 to about 30 degrees.

232. The method of claim 207, wherein said second doped sub-region is laterally offset from said transistor by a distance L_b.

233. The method of claim 232, wherein said distance L_b is equal to the gate stack's height multiplied by $\text{Tan}\theta_b$, where θ_b is in the range from about 0 to about 15 degrees.

234. An image pixel structure, said structure comprising:

a semiconductor substrate;

a gate stack with sidewall spacers on at least one side of the gate stack;

a photodiode adjacent to said gate stack, said photodiode having a doped surface region laterally offset from said gate stack by a distance L_a which is equal to said gate stack's height multiplied by $\text{Tan}\theta_a$, where θ_a is in the range from about 2 to about 30 degrees, wherein said doped surface region further comprises an undoped photodiode region.

235. A photoconversion device comprising:

a substrate having a surface;

a first region doped to a first conductivity type located below the surface of the substrate, said region having a dopant gradient profile;

a separation region; and

a second region doped to a second conductivity type located beneath said first doped region and separation region for collecting photogenerated charges.

236. An image pixel structure, comprising:

a substrate;

a transistor provided over said substrate;

a photoconversion device adjacent to said transistor comprising a photodiode formed within said substrate; and

a separation region provided within said substrate, said separation region formed between said photodiode and said transistor.

237. An imager system comprising:

(i) a processor; and

(ii) an imaging device coupled to said processor, said imaging device comprising at least one image pixel cell with a pinned photodiode structure, said photodiode structure comprising:

a first region doped to a first conductivity type located below the surface of the substrate, said region having a first sub-region and a second sub-region doped to said first conductivity type;

a separation region; and

a second region doped to a second conductivity type located beneath said first doped region and separation region for collecting photogenerated charges.

238. A processing system comprising: a processor; and an imager pixel device coupled to said processor, said imager pixel device comprising at least one photodiode region, said photodiode region comprising:

a first region doped to a first conductivity type located below the surface of the substrate, said region having a dopant gradient; and

a second region doped to a second conductivity type located beneath said first doped region for collecting photogenerated charges.

239. An image pixel structure, comprising:

a semiconductor substrate;

a transistor provided over said substrate; and

a pinned photodiode adjacent to said transistor and formed within said substrate, said pinned photodiode comprising a separation region formed between said transistor and said pinned photodiode.

240. A method of forming an image pixel structure, said method comprising:

providing a semiconductor substrate;

forming a gate stack with a gate oxide layer and a conductive layer;

forming a pinned surface layer of a photodiode, said pinned surface layer formed by at least one angled implant, wherein said angled implant is conducted at an angle from about 2 to about 30 degrees, wherein said angled implant creates a surface region adjacent to said gate stack that is an undoped photodiode region;

forming a charge collection region of a photodiode, said charge collection region formed by at least one angled implant, wherein said angled implant is conducted at an angle from about 0 to about 30 degree; and

forming sidewall spacers on at least one side of said gate stack.